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(54) **Superheterodyne receivers**

(57) A superheterodyne electric signal receiver for use at microwave frequencies and incorporating an image rejection mixing arrangement is of such a form as to facilitate fabrication of the receiver pre I.F. stages on one or more semiconductor chips. The mixing arrangement comprises first and second mixers (7, 9) whose outputs are combined in a hybrid coupler (21) to effect the required image rejection. The mixers are provided with respective local oscillator inputs via respective ones of a first pair of amplifiers (15, 19), and with respective radio frequency inputs via respective ones of a second pair of amplifiers (3, 5). The local oscillator amplifiers are suitably R.C. coupled to avoid the need for bias chokes. Quadrature local oscillator inputs for the mixers are suitably provided by feeding the output of the local oscillator to respective resistive loads via separate paths, one inductive the other capacitive, to avoid the use of large λ/4 transmission lines to provide such quadrature signals.

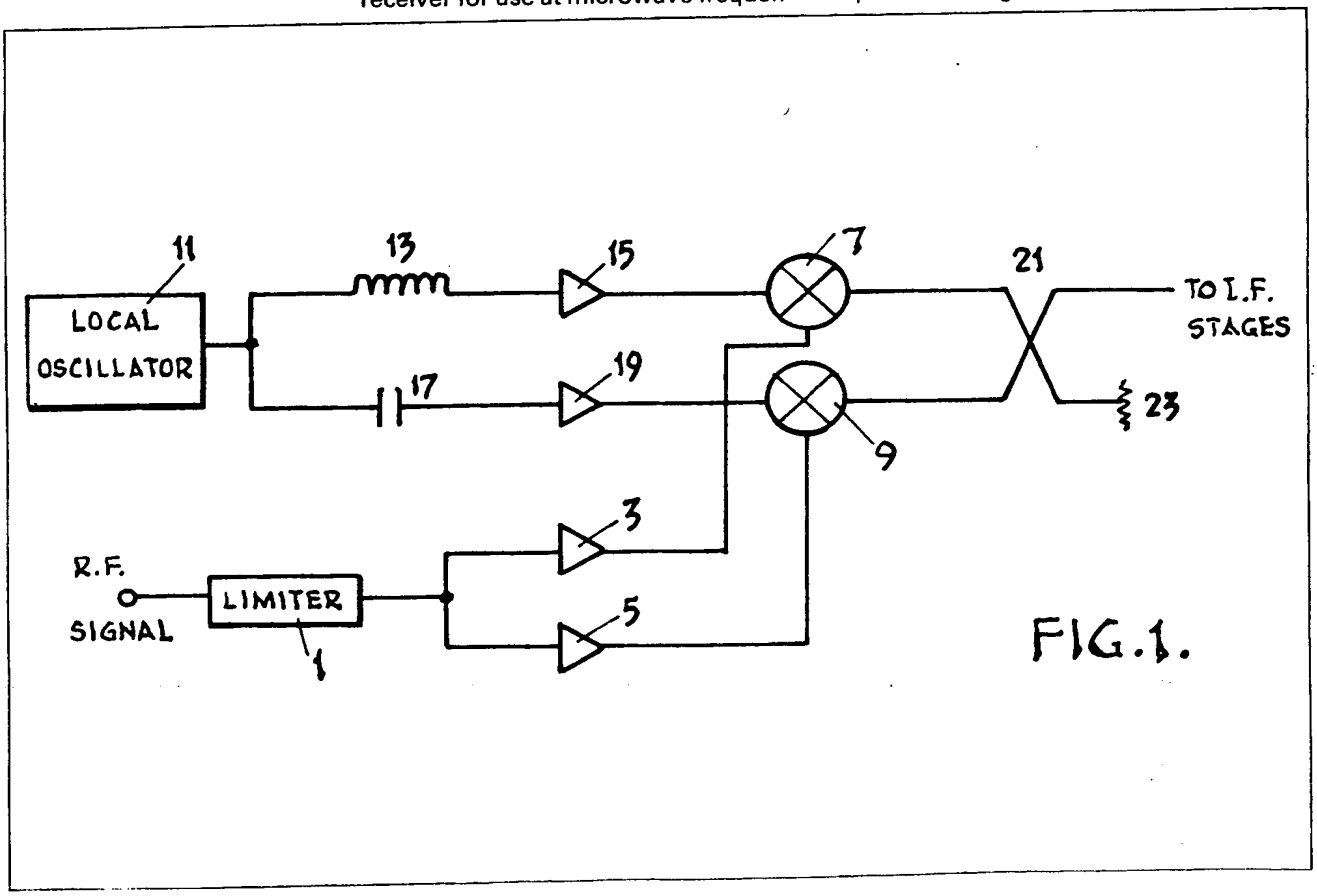

FIG.1.

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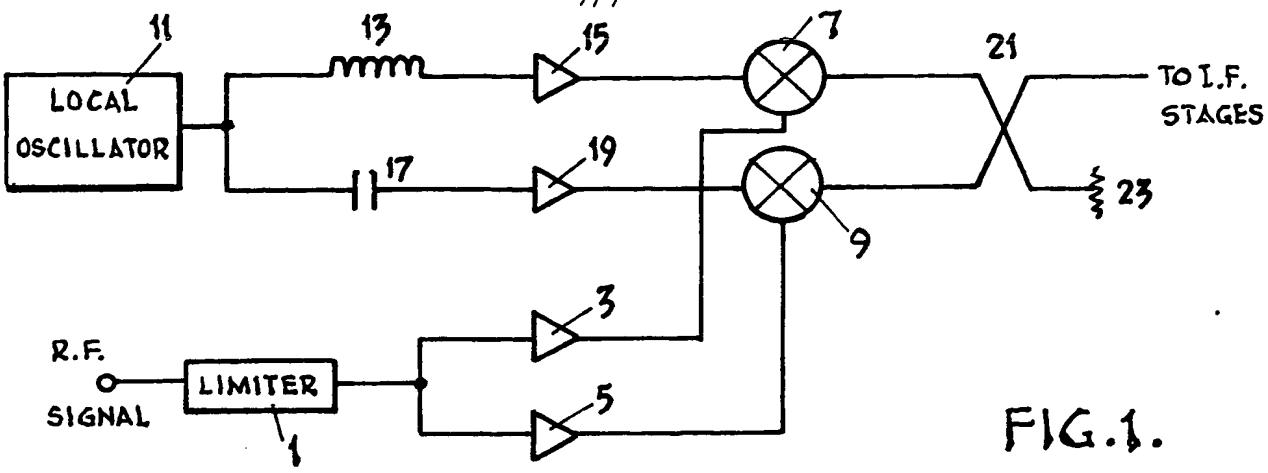

FIG.1.

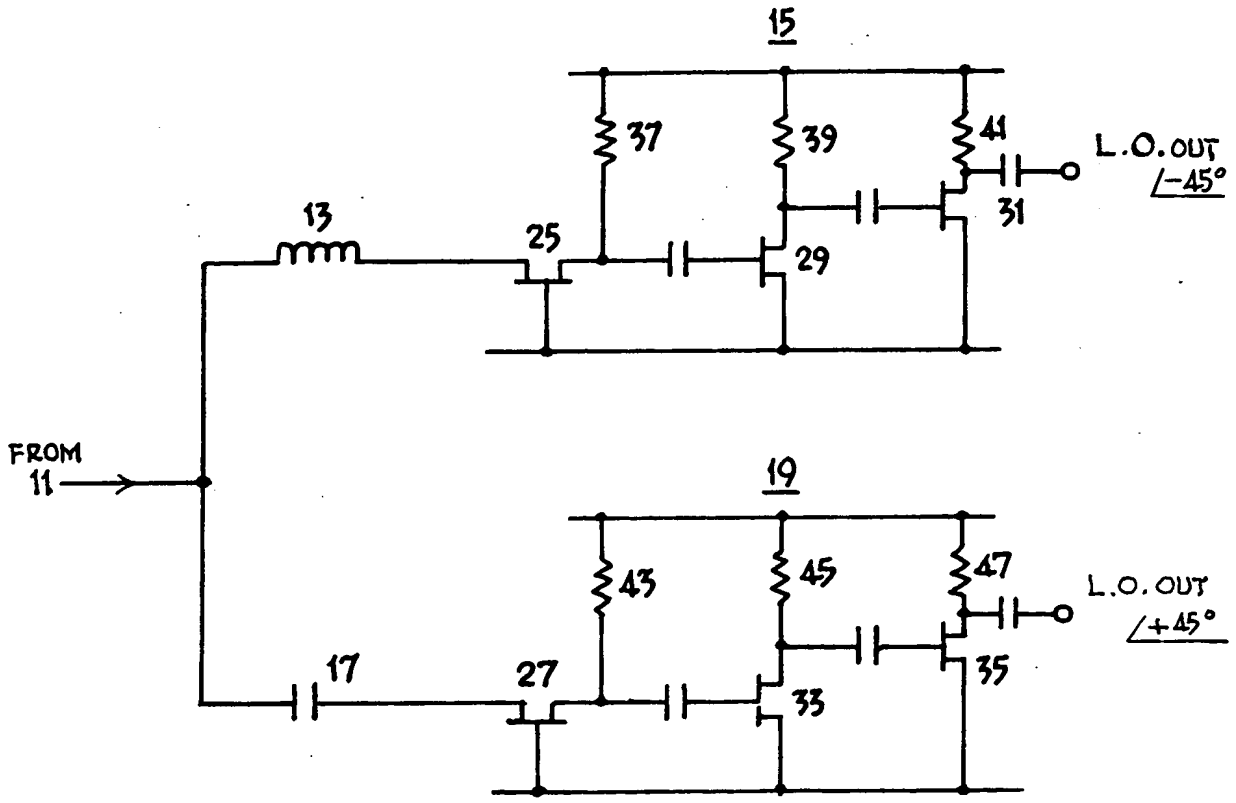

FIG.2.

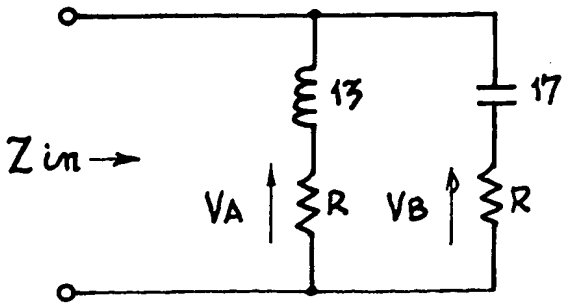

FIG.3.

SPECIFICATION

Superheterodyne electric signal receivers

This invention relates to superheterodyne signal receivers, more particularly such receivers for operation at microwave frequencies and incorporating an image rejection mixing arrangement.

The invention relates particularly to the stages of such a receiver preceding the I.F. amplification stages, and has as an object the embodiment of at least some of such stages in a form suitable for fabrication on a semi-conductor chip.

According to the invention there is provided a superheterodyne signal receiver, for use at microwave frequencies, incorporating an image rejection mixing arrangement comprising first and second mixers whose outputs are combined in a hybrid coupler to effect the required image rejection, the mixers being provided with respective local oscillator inputs by feeding the output of a local oscillator to the mixers via respective ones of a first pair of amplifiers, and the mixers being provided with respective radio frequency inputs by feeding the received radio frequency signal to the mixers via respective ones of a second pair of amplifiers.

In such an arrangement the mixer inputs are isolated from one another by the reverse isolation of the amplifiers. Each said mixer thus behaves as a single-ended device enabling the mixers to be of simple form utilising field effect transistors or diodes as their active elements, thus facilitating fabrication of the arrangement on a semiconductor chip.

In a receiver according to the invention said first pair of amplifiers are conveniently R.C. coupled amplifiers.

This enables bias to be applied to the active elements of the first pair of amplifiers via resistances, thus avoiding the use of bias chokes which would use a relatively large chip area if the amplifiers were fabricated on a semiconductor chip.

In a receiver in accordance with the invention either the local oscillator or signal inputs to the said mixers are, of course, required to be in quadrature. In one particular such receiver quadrature local oscillator signals for use in the said mixers are provided by feeding the output of the local oscillator to respective substantially resistive loads via separate paths, one inductive and the other capacitive.

This enables the required quadrature inputs to be obtained without the use of relatively large elements e.g. $\lambda/4$ transmission lines which would utilise a large chip area if the arrangement were fabricated on a semiconductor chip.

In one such particular receiver in accordance with the invention said loads comprise the input impedances of respective field effect transistors connected in common gate configurations. Preferably each said common gate configuration transistor is followed by at least one common source configuration field effect transistor amplifying stage, the various transistor stages being preferably R.C. coupled.

One superheterodyne receiver in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings in which:-

Figure 1 is a schematic diagram of the stages of the receiver preceding the intermediate frequency amplifier stage;

Figure 2 is a circuit diagram of one of the stages of Figure 1; and

Figure 3 is a diagram illustrating the operation of the stage shown in Figure 2

Referring to Figure 1, in the receiver the received radio frequency (R.F.) signal is fed by way of a limiter 1 to the inputs of two identical R.F. amplifiers 3 and 5 whose outputs are respectively fed to two mixers 7 and 9.

The receiver further includes a local oscillator 11 whose output is fed via an inductance 13 and an amplifier 15 to the mixer 7 and via a capacitance 17 and an amplifier 19 to the mixer 9.

The outputs of the mixers 7 and 9 are combined in a hybrid coupler 21, the input to the intermediate frequency (I.F.) stages (not shown) of the receiver being derived from one output of the coupler and a dummy load 23 being connected to the other output of the coupler.

In operation, the R.F. inputs to the mixers 7 and 9 are in phase while, as further explained below, the local oscillator inputs to the mixers are in quadrature. Hence, the wanted signal I.F. outputs produced by mixers 7 and 9 respectively differ in phase by 90° in one sense whilst the image signal I.F. outputs produced by mixers 7 and 9 respectively differ in phase by 90° in the opposite sense.

In the hydrid coupler 21 the wanted signal inputs from the mixers 7 and 9 appear in phase and the image signals in antiphase at the coupler output connected to the I.F. stages, while the image signal inputs from the mixers appear in phase and the wanted signals in antiphase at the coupler output connected to the dummy load 23. The arrangement thus operates as an image rejection mixing arrangement.

The quadrature local oscillator inputs are produced by arranging that the amplifiers 15 and 19 present equal resistive impedances R in series with the inductance 13 and capacitance 17 across the local oscillator output, the equivalent circuit network being shown in Figure 3. In such a network the voltages VA and VB across the resistances R are in quadrature at all frequencies; the input impedance Zin is equal to the resistance R at all frequencies; and the amplitude balance between the voltages VA and VB is within 0.5 dB over a 24% bandwidth.

Referring to Figure 2, the required resistances R are provided by using field effect transistors 25 and 27 connected in common gate configurations in the first stages of the amplifiers 15 and 19, Figure 2 showing the signal circuits of the amplifiers only and omitting gate bias components.

The outputs of the first stages of the amplifiers 15 and 19 are R.C. coupled to respective two-stage R.C. coupled amplifiers employing field effect transistors 29 to 35 connected in common source configurations.

The common gate stages provide an input impedance very close to a pure resistance of value equal

to the reciprocal of the transistor mutual conductance over a very wide bandwidth. The common source configuration is chosen for the subsequent stages to provide the common gate stages with stable load impedances.

Bias for the transistors of the amplifiers 15 and 19 is conveniently applied to the drains of the transistors via their respective drain resistors 37, 39, 41, 43, 45 and 47 and to the gates of the transistors via further resistors (not shown), thus avoiding the use of bias chokes.

The R.F. signal amplifiers may be of any suitable conventional design providing good reverse isolation.

The reverse isolation provided by the amplifiers 3, 5, 15 and 19 allows the mixers 7 and 9 to operate entirely independently giving freedom to optimise their design and operating conditions for the best dynamic range.

Furthermore, the quadrature related R.F. and local oscillator signals required for image rejection mixing are obtained without the use of conventional microwave phase shifters or filters which are difficult to fabricate in integrated circuit form. Moreover, the use of image rejection avoids image signal problems arising from noise generated in the R.F. amplifiers and allows sufficient local oscillator and R.F. amplification to be used to overcome the noise limitations of simple mixers.

All this facilitates fabrication of the mixers 7 and 9 in integrated circuit form using field effect transistors or diodes as the active elements without using complex technologies.

The various above mentioned features thus enable the R.F. amplifiers 3 and 5, the local oscillator amplifiers 15 and 19 and the mixers 7 and 9 to be all fabricated on one or more semiconductor chips, typically a gallium arsenide chip. The or each chip is suitably mounted on a ceramic substrate, and interconnections and any less easily integrated components, e.g. component 21, are fabricated using conventional thick or thin film technology.

The limiter 1 and the I.F amplification stages can also be fabricated in integrated form, but as silicon rather than gallium arsenide devices due to the poor carrier lifetime and high noise at low frequency characteristics of gallium arsenide field effect transistors.

CLAIMS

1. A superheterodyne signal receiver, for use at microwave frequencies, incorporating an image rejection mixing arrangement comprising first and second mixers whose outputs are combined in a hybrid coupler to effect the required image rejection, the mixers being provided with respective local oscillator inputs by feeding the output of a local oscillator to the mixers via respective ones of a first pair of amplifiers, and the mixers being provided with respective radio frequency inputs by feeding the received radio frequency signal to the mixers via respective ones of a second pair of amplifiers.

2. A receiver according to Claim 1 wherein said first pair of amplifiers are R.C. coupled amplifiers.

3. A receiver according to Claim 2 wherein said R.C. coupled amplifiers utilise field effect transistors to which bias is applied via resistances.

4. A receiver according to any one of the preceding Claims wherein quadrature local oscillator signals for use in said mixers are provided by feeding the output of the local oscillator to respective substantially resistive loads via separate paths, one inductive and the other capacitive.

5. A receiver according to Claim 4 wherein said loads comprise the input impedances of respective field effect transistors connected in common gate configurations.

6. A receiver according to Claim 5 wherein each said common gate configuration transistor is followed by at least one common source configuration field effect transistor amplifying stage.

7. A receiver according to Claim 6 wherein the various transistor stages are R.C. coupled.

8. A receiver according to any one of the preceding Claims wherein said amplifiers and said mixers are all fabricated on one or more semiconductor chips.

9. A superheterodyne signal receiver substantially as hereinbefore described with reference to the accompanying drawings.

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